

Land Surveys Interim Guidelines for the use of U.S. Customary Units

A) Land Surveys (Surveys and Right of Way Engineering)

This functional unit primer is to be considered an “interim” document for use until all the appropriate Departmental manuals, plans, specifications, and any other document dictating the requirements of the work and products of Land Surveys have been converted to US Customary Units. They are to be used for any transportation improvement project on state facilities using US Customary Units until then.

General

- 1) Conversion factor from meters to feet:

As stated in Table 1, the exact conversion factor from meters to feet is 3937feet/1200meters (the US Survey Foot).

- 2) Conversion factor from hectare to acre:

Multiply the hectare value by $((3937/12)**2)/43560$ to get the acre equivalent.

Hardware/Software

- 1) The Party Chief shall ensure that the survey instrumentation is configured to collect data in the U.S. survey foot. Also, the survey reduction and adjustment software shall be configured to use the U.S. survey foot.

Interim Revisions to Caltrans Surveys Manual (CSM)

- 1) The monumentation spacing requirements shown on Figure 5-1, “Caltrans Orders of Survey Accuracy” of the CSM will be ignored.
- 2) The following vertical accuracy standards will replace the requirements shown in figure 5-1:

First order: $f = \pm 0.02(\sqrt{M})$

Second order: $f = \pm .035(\sqrt{M})$

Third order: $f = \pm .05(\sqrt{M})$

These reflect the closure between established control where f is the maximum misclosure in feet and M is the distance in miles.

- 3) The following table will replace the corresponding rows of Table 6A-1 in chapter 6 of the CSM:

Table 6A-1 First Order (Horizontal) GPS Survey Specifications

Specification	Static	Fast Static
General Network Design		
Maximum distance between the survey project boundary and network reference stations	31 miles	31 miles
Office		
Initial position: maximum 3d position error for the initial station in any baseline solution	32 feet	32 feet
Maximum loop length	62 miles	62 miles
Maximum misclosure per loop in any one component (x,y,z) not to exceed	0.15 foot	0.15 foot
Repeat baseline length not to exceed	31 miles	31 miles
Maximum residual in any one component (x,y,z) in a properly weighted least squares adjustment	0.1 foot	0.1 foot

- 4) The following table will replace the corresponding rows of Table 6A-2 in chapter 6 of the CSM:

Table 6A-2 Second Order (Horizontal) GPS Survey Specifications

Specification	Static	Fast Static
General Network Design		
Maximum distance between the survey project boundary and network reference stations	31 miles	31 miles
Office		
Initial position: maximum 3d position error for the initial station in any baseline solution	65 feet	65 feet
Maximum loop length	47 miles	47 miles
Maximum misclosure per loop in any one component (x,y,z) not to exceed	0.25 foot	0.25 foot
Repeat baseline length not to exceed	31 miles	31 miles
Maximum residual in any one component (x,y,z) in a properly weighted least squares adjustment	0.25 foot	0.25 foot

- 5) The following table will replace the corresponding rows of Table 6A-3 in chapter 6 of the CSM:

Table 6A-3 Third Order (Horizontal) GPS Survey Specifications

Specification	Static	Fast Static	Kinematic
General Network Design			
Maximum distance between the survey project boundary and network reference stations	31 miles	31 miles	31 miles
Office			
Initial position: maximum 3d position error for the initial station in any baseline solution	325 feet	325 feet	325 feet
Maximum loop length	31 miles	31 miles	31 miles
Maximum misclosure per loop in any one component (x,y,z) not to exceed	0.32 foot	0.32 foot	0.32 foot
Repeat baseline length not to exceed	6.2 miles	6.2 miles	6.2 miles
Maximum residual in any one component (x,y,z) in a properly weighted least squares adjustment	0.32 foot	0.32 foot	0.32 foot

- 6) The following table will replace the corresponding rows of Table 6A-4 in chapter 6 of the CSM:

Table 6A-4 General Order (Horizontal) GPS Survey Specifications

Specification	Kinematic
General Network Design	
Maximum distance between the survey project boundary and network reference stations	6.2 miles

- 7) The following table will replace the corresponding rows of Table 6A-5 in chapter 6 of the CSM:

Table 6A-5 Vertical GPS Survey Guidelines

Specification	0.066 feet	0.164 feet
General Network Design		
Maximum distance between project survey stations	6.2 miles (avg. 4.3 miles)	12.4 miles (avg. 7.5 miles)
Office		
Initial position: maximum 3d position error for the initial station in any baseline solution	32 feet	32 feet
Maximum ellipsoid height difference per repeat baseline	0.07 foot	0.16 foot
Apply NGS geoid height model	Always	Always
Maximum RMS values of processed baselines (2 sigma)	0.05 foot	0.05 foot

- 8) The following table will replace the corresponding rows of Table 6B-1 in chapter 6 of the CSM:

Table 6B-1 Third Order RTK Survey Specifications

Specification	RTK Survey
Field	
Horizontal precision of the measurement data for each observation	Less than or equal to 0.03 foot
Vertical precision of the measurement data for each observation	Less than or equal to 0.05 foot
Maximum residual of the horizontal coordinates for the horizontal RTK control stations in the GPS calibration	0.07 foot
Maximum residual of the height for the vertical RTK control stations in the GPS calibration	0.1 foot
Maximum distance from the base station to the rover unit(s)	6.2 miles
Maximum difference in horizontal coordinates of the second occupation from the first occupation	0.07 foot
Maximum difference in height of the second occupation from the first occupation	0.14 foot

- 9) The following table will replace the corresponding rows of Table 6B-2 in chapter 6 of the CSM:

Table 6B-2 Third Order RTK Survey Specifications

Specification	RTK Survey
Field	
Horizontal precision of the measurement data for each observation	Less than or equal to 0.05 foot
Vertical precision of the measurement data for each observation	Less than or equal to 0.07 foot

- 10) The following table will replace the corresponding rows of Table 7-1 in chapter 7 of the CSM:

Table 7-1 Second Order (Horizontal) TSSS Survey Specifications

Specification	Traverse/Network
Distance rejection limit; residual not to exceed	0.01 foot + 2ppm
Minimum distance measurement	330 feet

- 11) The following table will replace the corresponding rows of Table 7-2 in chapter 7 of the CSM:

Table 7-2 Second Order (Vertical) TSSS Survey Specifications

Specification	Trigonometric Leveling
Difference between two DEs for each setup not to exceed	0.005 foot
Maximum sight length	230 feet
Minimum ground clearance of line of sight	3.28 feet
Difference between backsight and foresight lengths not to exceed	33 feet

- 12) The following table will replace the corresponding rows of Table 7-3 in chapter 7 of the CSM:

Table 7-3 Third Order TSSS Survey Specifications

Specification	Trigonometric Leveling
Minimum distance measurement to meet horizontal accuracy standard	165 feet
Distance rejection limit: residuals not to exceed	0.01 foot + 2 ppm
Maximum distance measurement to meet vertical accuracy standard	330 feet

- 13) The following table will replace the corresponding rows of Table 7-4 in chapter 7 of the CSM:

Table 7-4 General Order TSSS Survey Specifications

Specification	Trigonometric Leveling
Minimum distance measurement to meet horizontal accuracy standard	65 feet
Maximum distance measurement to meet vertical accuracy standard	500 feet

- 14) The following table will replace the corresponding rows of Table 8-1 in chapter 8 of the CSM:

Table 8-1 Second Order Differential Leveling Specifications

Operation/Specification	Compensator-Level Three- Wire Observation	Electronic/Digital Bar Code Level
Difference in length between fore and back sites, not to exceed per setup	16 feet	16 feet
Cumulative difference in length between fore and back sights, not to exceed per loop or section	33 feet	33 feet
Maximum sight lengths	230 feet	230 feet
Maximum ground clearance of sight line	1.6 feet	1.6 feet
Maximum section misclosure	0.035 feet(\sqrt{M})	0.035 feet(\sqrt{M})
Maximum loop misclosure	0.035 feet(\sqrt{M})	0.035 feet(\sqrt{M})

Note: M is the shortest one-way length of section or length of loop. Also, readjust level if 0.007 feet in 200 feet is exceeded.

- 15) The following table will replace the corresponding rows of Table 8-2 in chapter 8 of the CSM:

Table 8-2 Third Order Differential Leveling Specifications

Operation/Specification	Compensator-Level Three- Wire Observation	Compensator-Level Single-Wire Observation	Electronic/Digital Bar Code Level
Difference in length between fore + back sights, not to exceed per setup	33 feet	33 feet	33 feet
Cumulative difference in length between fore and back sights, not to exceed	33 feet	33 feet	33 feet
Maximum sight lengths	300 feet	300 feet	300 feet
Maximum ground clearance of sight line	1.6 feet	1.6 feet	1.6 feet
Maximum section misclosure	0.05 feet(\sqrt{M})	0.05 feet(\sqrt{M})	0.035 feet(\sqrt{M})
Maximum loop misclosure	0.05 feet(\sqrt{M})	0.05 feet(\sqrt{M})	0.035 feet(\sqrt{M})

Note: M is the shortest one-way length of section or length of loop. Also, readjust level if 0.007 feet in 200 feet is exceeded.

- 16) The following DTM survey guidelines will be used for spacing and accuracy of survey measurements as a replacement to the corresponding requirements in Chapter 11, "Engineering Surveys" of the Caltrans Surveys Manual (CSM):

DTM survey guidelines:

- Take shots on breaklines at approximately 50 feet intervals and at changes in grade.
- Locate data points at high points and low points and on a grid of approximately 50 feet centers when the terrain cannot be defined by breaklines.
- Take shots on curves with a radius of 300 feet or less at 25 feet.
- Gather one extra line of terrain points 15 to 25 feet outside the work limits.

Accuracy Standard: Data points located on paved surfaces or any

engineering works should be located within +/- .05 foot horizontally and +/- .02 foot vertically. Data points on original ground should be located within +/- .1 foot horizontally and vertically.

- 17) The following accuracy requirements for spot location or monitoring surveys will replace the requirements in Chapter 11 of the CSM:

Accuracy Standard: Data points located on paved surfaces or any engineering works should be located within +/- .05 foot horizontally and +/- .02 foot vertically. Data points on original ground should be located within \pm .1 foot horizontally and vertically.

- 18) The following accuracy requirements for vertical clearance surveys will replace the requirements in Chapter 11 of CSM:

Accuracy Standard: Data points located on paved surfaces or any engineering works should be located within +/- .05 foot horizontally and +/- .02 foot vertically. Data points on original ground should be located within \pm .1 foot.

- 19). The following control accuracy and base station location requirements for airborne GPS (ABGPS) photogrammetry surveys will replace the requirements in Chapter 13, Appendix D of the CSM:

Control

- Base stations ellipsoid heights shall have a standard error of not more than 0.06 feet.
- Photo control ellipsoid heights shall have a standard error of not more than 0.06 feet.
- Caltrans second order differentially leveled orthometric heights on targets a maximum of every 1.2 miles throughout the ABGPS project.

Base Station Location

- One station within 0.5 miles of the project Airport.
- One station within 0.5 miles of each end of the project.
- Additional stations at 20 mile spacing throughout the project.

Interim Guidelines for Right of Way Engineering Products

- 1) Unit Equivalent mapping scales will be used.

- 2) For mapping based on the standard sheet size of 22" x 34" (Cost Estimate Maps*, Hardship/Protection Maps*, Appraisal Maps, Federal Lands Application Maps, Freeway Lease Area Maps{Appraisal}), and maps that are required to be 22" x 36" **(State Lands Application Maps, Transfer of Jurisdiction Maps, Right of Way Record Maps, Relinquishment/Vacation Maps), the typical scales will be:

1" = 50' for urbanized areas

1" = 100' for rural areas

1" = 1000' for Index Maps

*These maps will be developed on existing mapping and then placed into the 22" x 34" sheet.

** 22" x 36" required by statute. The base for these maps will be the Appraisal Map, but will be printed on a 22" x 36" sheet.

- 3) For mapping based on an 8.5" x 11" standard sheet size (Director's Deed plats, Resolution of Necessity plats, Freeway Lease Area Maps{Inventory}) the scale will be determined by the amount of detail needed.
- 4) When needs dictate the use of a non-typical mapping scale, the mapping scale chosen must be directly readable from a standard Engineer's scale for English units.